

Apparatus for Selectively Moving Hydrogen Ions in Aqueous Solutions

Background of the Invention

1. Field of the Invention

[0001] The present invention relates to an apparatus for use in medical appliances, thermal therapy and pH measurement, and in particular, to an apparatus for selectively moving hydrogen ions in aqueous solution.

2. Description of the Related Art

[0001] Water is a major part of an organism, which can thus be considered as a water container. Water molecule is a simply H_2O ; however, it tends to crystallize due to its polarity and hydrogen bond. There exist hundreds of various forms of crystals as water transforms into solid ice. Water, even in liquid, is able to form a subcrystalline structure with a range of 5-20 molecules. In the art of heating water molecules in organisms, there are supersonic heating and microwave heating in frequency of 2.2 GHz.

[0002] In liquid water, the hydrogen ion can jump along the directions of hydrogen bonds; therefore, the hydrogen ion is the most mobile among all the ions. Because of this property, the hydrogen ions can be moved under extremely low electric field. Using higher potential and thus larger electric field, the mobility of the hydrogen ions can be increased so as to achieve the object of measuring pH value or producing heat. Nevertheless, in case the potential used is too high, the other ions are going to be moved as well, and there will be no efficacy of selectively moving the hydrogen ions. As a result, the threshold of the applied

potential will be that of not inducing electrolysis in water. On the other hand, even if a potential is constantly and fixedly applied for non-electrolyzing liquid water, the ions, such as sodium, potassium, chloride, etc., can still be moved and generate transient ionic current.

Summary of the Invention

[0003] The present invention discloses an apparatus for selectively moving hydrogen ions in aqueous solutions with high frequency and low potential, and to generate specific currents.

[0004] It was found that according to the present invention, the rapid alternation in potential is able to avoid the generation of the aforementioned ionic current. If the frequency of alternating the applied potential is faster than 1 millisecond (ms), the hydrogen ions will first be moved, which generates a transient current. Since the field is greatly reduced by the movement of hydrogen ions and each of the other ions may carry 4-11 water molecules, which results in significantly increase in the mass and viscosity of liquid water, the other ionic current generated by the movement will be significantly reduced. The jumping of hydrogen ions along the subcrystalline water is similar to that of the holes in semiconductor, and thus produces a significant level of current.

[0005] When the applied potential constantly increases, water may be electrolyzed and nerve and muscle existing in the organism may also be excited. In the organism body, when the electric current by an electric field lasts shorter than 1 ms, the nerve and muscle can avoid excitation, which will subsequently generate a large amount of Na^+ and K^+ current. Therefore, the rapid alternation in electric field of + to - is deemed important to selectively moving H^+ and H^+ only. While 1 ms is

just a safe lower limit for not exciting nerve and muscle, and electrolyzing water, in practice, the frequency can be higher than 1 MHz (10^6 Hz) so that the selectivity to the H^+ movement will be more dominant in the generated current. The selectivity to the H^+ movement will be even higher in case the pH drops and the concentrations of other ions in the aqueous solution also reduce, which can avoid destructing the subcrystalline structure of water.

[0006] There exist a variety of ways to monitor the possible electrolysis of water (or excitation of muscle and nerve) that may reduce the efficacy of the apparatus according to the present invention. Two of them are exemplified here. The first one is to directly detect the generated current, for the current will be subject to a sudden change in case of water electrolysis. The second is monitoring through the ultrasound reflection. If the water is electrolyzed, the air bubbles will generate and increasingly scatter ultrasound around the electrode. After the parameters in certain bio-systems, e.g., specific electrode, applied potential and frequency, are collected, these parameters can be directly applied without using the monitoring system. In an alternating field of using positive and negative currents in square wave, the net current can change in maximum scale without exciting nerve and muscle or electrolyzing water. On the other hand, the waveform supplied from a step field has the most harmonics at high frequency, which can increase the mobility of the H^+ . Under this condition, the current can be used as an indicator of hydrogen ion concentration. The lower the pH is, the larger the current is. Physiologically, this current can be used as a pH meter. When the pH value at a specific spot is desired, a tiny electrode can be penetrated into the spot for measurement, as shown in Figure 1. The generated current

will concentrate at the surface of the tiny electrode. The pH value around the electrode can thus be calculated with respect to the current.

[0007] For medical purposes, the apparatus according to the present invention can be used to detect early stage of cancer. At this stage, the cancer tissue usually consumes glucose via glycolysis and the topical pH value will decrease due to production and accumulation of lactate. According to the current of H^+ selectively generated by the apparatus of the present invention, any existence of subject with abnormal acidity (and thus abnormal current) can be targeted. Along with a specific arrangement of the electrodes, the size as well as shape of the possibly existing cancer can be further determined. Once the area of cancer tissue is determined, the abnormal current can be used to specifically heat the area. This heat produced will be automatically concentrated in the low pH or the malignant area.

[0008] Other features and advantages of the present invention will be apparent from the accompanying drawings and from the detailed description that follows below.

Brief Description of the Drawings

[0009] Figure 1 is an assembly of an electrode pair for moving hydrogen ions in vicinity of a electrode 2, in which 1 is an electrode with a larger area and 2 is an electrode with a smaller area.

[0010] Figure 2 schematically shows in the application of human body an assembly of a plurality of electrode pairs, in which each 3 are as a group for moving the hydrogen ions between the electrode groups, especially in the crossing point of electric field for each group of electrode pairs.

Detailed Description of the Preferred Embodiments

[0011] The simplest way of positioning target is to place each of the tiny electrodes as a concentrated point of electrical field. The electrodes will possess the highest electric field at the surface of the tiny electrode. Since overheat at the surface should be prevented, a temperature sensor (e.g., a thermal couple or platinum wire) can be added hereinto to monitor the temperature and control the current. In case of several electrodes working cooperatively without the tiny electrode for positioning as shown in Figure 2, one may estimate the resistance through the electrode pairs as well as the current path, and then conduct the current through the target. If the each electrode pair leads current passing the target, the plurality of electrode pairs may work at the same time or each at a different time to lead the current passing the target. The heating effect will be amplified by N times at the target, comparing to other parts of the body. While the electric field is a vector if the field at the target can be added together, the N pairs of electrode will produce N^2 times of the heat at the target compared with other parts of the body. At the target with lower pH, the concentration of H^+ current thus becomes even larger and thus will further increase the heating effect at the target.

[0012] In application, distant electrodes may be configured together with the tiny electrodes at the target. They render the benefit of both methods together, in addition to that of the temperature feedback. The target can also be positioned at a region with poor blood circulation, such as that in organs, sore muscle or fat layer. It can be used for treating cancer, weak organ, bone injury, and muscle injury, as well as reducing fat deposit, losing weight and shaping the body.

[0013] This kind of hydrogen ion measurement can change the subcrystalline structure of water; therefore, it can reduce the viscosity in a small tube where the ionic force can be strong. This application will be very useful in artificial machines such as MEMS (Micro-Electro Machinery) or biochips. It may also be used in natural tissues such as microcirculation to improve biological fluid (e.g., blood) circulation and to reduce the viscosity.

[0014] The electrical field can also be generated through change in magnetic field in terms of $(dB/dt) = \text{curl}(E)$. If the magnetic field is changed with time at the target, the induced electric field will be generated. If the magnetic field changes rapidly, the electric field will also be instantly generated and then selectively move the H^+ . By arranging conducting coil around the body, the maximum magnetic field can be generated in vicinity of the target. The required electric field can thus be induced from the change in the magnetic field. Several magnetic fields can be cooperatively applied to generate a group of electric field analogue to the electrode pairs.

[0015] At the interface of the electrode and the body, gel is preferably applied to lower the impedance in the apparatus according to the present invention. The gel is mainly composed of electrolyte. If the gel is very low in pH, the H^+ will be high in concentration. As a result, it is preferable to choose solutions with a low pH as the interfacial medium between the electrode and body. As far as the compatibility is concerned, an organic acid such as acetic acid and lactic acid will be a preferable choice. The impedance across the interface will thus be significantly reduced so as to decrease the heat generated at the interface as well as to increase the passage of the electrical signal which improves the signal to

noise (S/N) ratio during measurement.

[0016] This gel can be used alone for acquiring EEG, ECG, or EMG as a signal process gel, or used as an electric simulator gel to improve the efficiency of the stimulation by lowering the interface impedance as well as heat generated from the interface. Because of the low pH ingredient in the medium, the resistance can be reduced, especially the impedance at high frequency and thus significantly increase the efficacy of the apparatus according to the present invention.

[0017] By the foregoing description, various processes embodying the present invention have been disclosed. However, numerous modifications and substitutions may be made without deviating from the scope of the present invention. Therefore, the above illustration is to disclose the present invention but not to limit the scope thereof.